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Publication date:
1987

Document Version
Publisher's PDF, also known as Version of record

RISØ

Risø-M-2658

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October 1987

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Abstract: A survey is given of archaelogical samples dated in 1986 at the Nordic Laboratory for Thermoluminescence Dating. A total of 56 samples were dated. The results were corrected for short-term fading as measured for samples stored for four weeks either at room temperature or at 100 °C. The beta dose from potassium and rubidium in feldspar and the alpha dose from uranium and thorium in quartz and feldspar grains were included assuming alpha efficiency factors of 0.1 and 0.2 for quartz and feldspar, respectively.

INIS-DESCRIPTORS: AGE ESTIMATE; ARCHAEOLOGICAL SPECIMENS; DENMARK; FINLAND; NORWAY; SWEDEN; THERMOLUMINESCENCE

October 1987
Risø National Laboratory, DK-4000 Roskilde, Denmark

ISBN 87-550-1344-9
ISSN 0418-6435

Grafisk Service, Risø 1987

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INTRODUCTION

TL dating results for archaeological materials measured in 1986 are presented. The materials included ceramics, bricks, burnt clay and burnt stones. A total of 56 samples are discussed (Table 1). Surveys of samples dated in the three previous years are given by Mejdahl (1984a, 1985, 1986). The distribution of archaeological samples dated in the period 1983-85 is shown in Table 2.

Table 1. Archaeological samples from the Nordic countries dated in 1986 at the Nordic Laboratory for TL dating.

Material	No. of samples	Percent
Ceramics	11	20
Bricks/tiles	14	25
Burnt clay	7	12
Burnt stones	24	43
Total	56	100

Table 2. Archaeological samples from the Nordic countries dated in 1983, 1984 and 1985 at the Nordic Laboratory for TL dating.

Material	No. of samples	Percent
Ceramics	44	17
Bricks	18	7
Burnt clay	36	14
Burnt stones	163	62
Total	261	100

TL DATING TECHNIQUE

As before, the additive dose technique with a supralinearity correction (Aitken 1985) was used. Three groups of minerals: K-feldspar (~12% K), Na-feldspar (~ 5% K) and quartz were separated using the heavy liquid technique. The liquids were aqueous solutions of sodium metatungstate, $3\,Na_2WO_4.9WO_3.H_2O$. The grain size was in the range 0.1 - 1 mm. The dating technique and methods for estimating the dose contributions from internal Rb, U and Th in the quartz and feldspar grains are outlined in Mejdahl (1986, 1987).

The automated Risø TL reader (Bøtter-Jensen et al. 1983, Bøtter-Jensen 1987) was used throughout for measuring the TL. The laboratory now has three reader systems in operation.

SHORT-TERM FADING

During the last few years it has become clear that special attention must be paid to the effect of short-term fading of feldspar. Our standard procedure has been to apply a correction factor obtained by comparing the TL signals from two sets of samples that were given doses of 40 Gy in addition to their natural dose. There was a four-week interval between sets of doses, and measurements were made immediately after the irradiation of the second set. Storage was at room temperature.

TL dating results for burnt stones from a neolithic site at Vuollerim, Norrland, Sweden (Mejdahl 1985) indicated that this fading correction was insufficient. The results showed a considerable scatter ranging from 220 AD to 4180 BC in contrast with the archaeological evidence and three radiocarbon dates in the interval 5000 - 6300 BP. Similar aberrant TL results were later found for burnt stones from a Bronze Age site at Højgård, Gram, Denmark (see page 14).

The localised transition model for short-term fading proposed by Templer (1986) indicates that the fading can be accelerated by storing samples at elevated temperatures rather than at room temperature. Following this model we stored samples at 100°C for periods ranging from one to four weeks. The second set of samples was also kept at 100°C until both were irradiated. Some of the results obtained are shown in Fig. 1. Curves A and B reach constant levels of 0.90 and 0.60, respectively, in two weeks; consequently, one might conclude that these would be proper correction factors.

This would certainly be acceptable for sample A in Fig. 1, but one would hesitate to apply a fading correction as large as 40% corresponding to a level at 0.60. The procedure under consideration is to measure short-term fading by storing all samples at 100°C for at least two weeks and rejecting those that fade more than 20%.

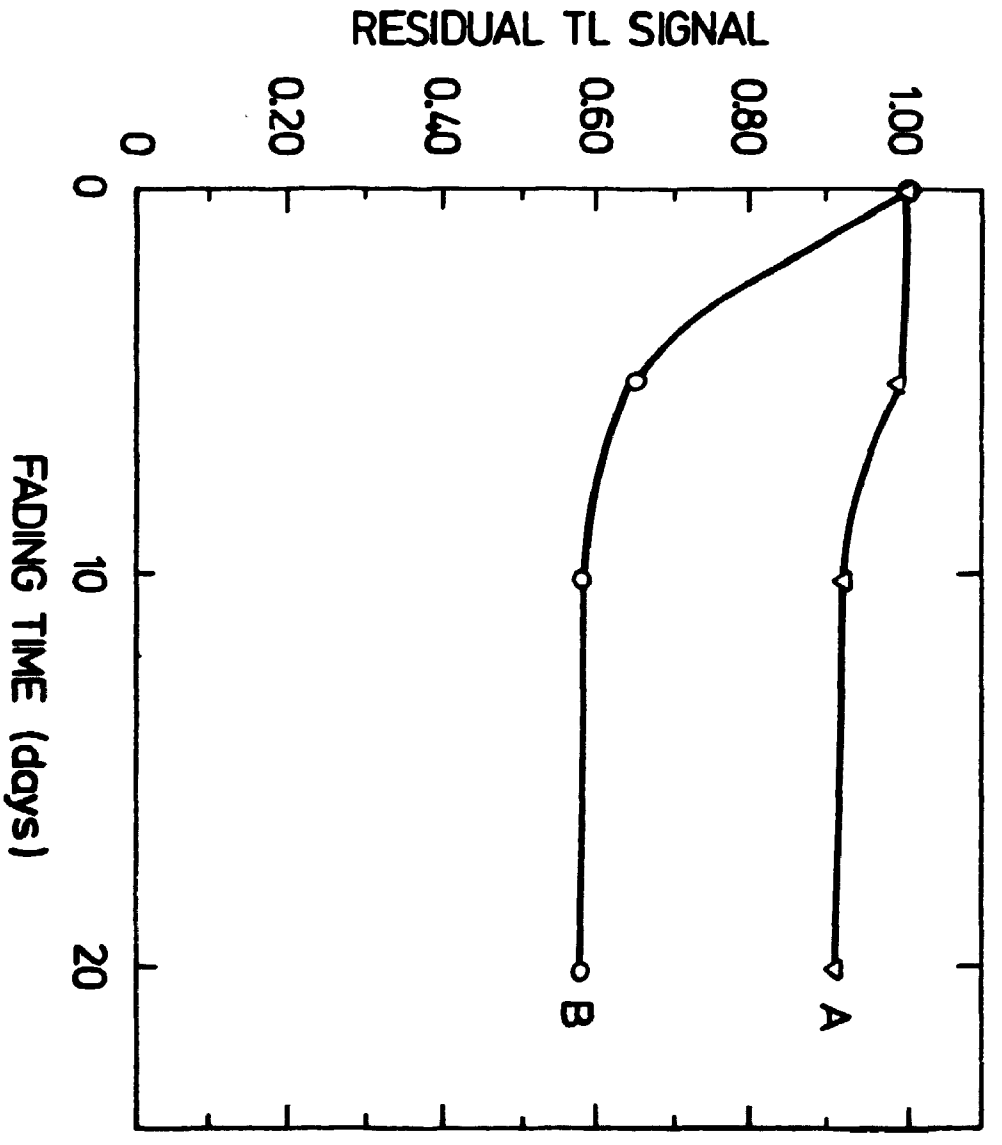

Fig. 1. Fading of the TL signal in feldspars extracted from burnt stones from (A) Lindholm, Sweden and (B) Stedstrup, Denmark. Storage was at 100°C for the periods indicated. The TL signal was averaged over the temperature interval 350-400°C. Heating rate 16°C/s.

COMMENTS ON THE PRESENTATION OF DATING RESULTS

In the following, tables with beta and gamma (including cosmic ray) doses are given. The beta doses are infinite matrix values usually measured on dry samples for pottery and clay and wet samples for stones.

The average beta dose received by a grain will depend on grain size and its potassium and rubidium contents. The dose was calculated using attenuation factors and absorbed fractions from Mejdahl (1979). The tables also include U contents of feldspar grains and fading of feldspars over four weeks at room temperature.

Additional tables list the TL dates obtained together with and uncertainty factor including random and systematic errors at the 1σ level. The calculation of the uncertainty is described in Mejdahl (1984b).

TL DATING RESULTS, DENMARK

A total of 32 samples from 5 Danish sites are discussed below.

1. Sejlflod near Aalborg

In the period 1979-85 extensive excavations have been carried out at Sejlflod under the direction of Jens N. Nielsen (Nielsen and Rasmussen 1986, Nielsen 1987), Aalborg Historical Museum. The finds included a large cemetery with more than 300 graves from the period 300-500 AD and several pahses of a village comprising more than 100 houses, 80 of which spanned the period 400-1100 AD. Earlier TL dating projects dealing with samples from Sejlflod that were mainly burnt stones, have been described by Mejdahl (1984a, 1986).

The present series consists of burnt stones from postholes collected by Jens N. Nielsen. Thirteen stones were received, but only 5 were suitable for dating. The environmental radiation was not measured, but since the radiation field in the area is very uniform and constant with time, the average value of earlier measurements, 0.70 mGy/a, was used. Infinite matrix beta dose rates, U-content of the grains and fading over four weeks are given in Table 3 and the TL dating results are listed in Table 4.

Table 3. Beta dose rate, U-content of grains, and fading over four weeks for feldspars from burnt stones from Sejlflod. Gamma dose rate 0.70 mGy/a. R-862916 is quartz, the others are feldspar.

Risø TL no.	House	Feature no.	Beta dose rate (mGy/a)	U-content (ppm)	Fading 4 weeks
R-862903	-	6722	4.32	0.37	0.90
R-862907	ASC	9064	4.24	0.03	0.89
R-862908	ATC	9869	6.04	0.55	0.96
R-862912	-	9918	3.79	0.09	0.94
R-862916	ATA	9928	4.97	2.00	1.00

Table 4. TL dates for quartz and feldspars from burnt stones from Sejlflod. R-862916 is quartz, the others are feldspar.

Risø TL no.	House	Feature no.	TL date
R-862903	-	6722	290 AD +/- 100 a
R-862907	ASC	9064	810 AD +/- 60 a
R-862908	ATC	9869	730 AD +/- 80 A
R-862912	-	9918	510 AD +/- 80 a
R-862916	ATA	9928	610 AD +/- 80 a

Apart from R-862903 which is somewhat older than expected the results agree well with archaeological estimates.

2. Prestestien near Esbjerg

The excavation of Prestestien was carried out during 1984-86 by Esbjerg Museum under the direction of Palle Siemen. The site contained remains of a village from the Younger Iron Age consisting of ordinary houses and pit houses. Adjacent to the village a cemetery containing more than 50 graves was encountered. Based on ceramics, house types and the find of two bronze fibulae the site was estimated to date from the period 400-700 AD. Near the Iron Age village a Viking Age settlement was encountered.

The environmental radiation was measured at 19 localities at the Iron Age site during the 1985 excavation (Fig. 2). The mean value was 0.5% mGy/a with a standard deviation of 7%. Because of the uniformity of

the radiation field the mean value was used for calculating the age. The beta dose rates, U-contents and fading over four weeks at 20°C and two weeks at 100°C (for three samples) are listed in Table 5 and the TL dating results are given in Table 6. Where available the results for storage at 100°C were used for fading corrrections.

Fig. 2. Measurement of environmental radiation at Præstestien, Denmark.

Table 5. Water uptake W (W = weight saturated/weight dry), beta dose rates, U-contents of grains and fading of feldspars over four weeks for ceramics from Præstestien.

Risø TL no.	W	Beta dose rate (mGy/a)	U-content (ppm)	Fading 4 weeks 20°C	Fading 2 weeks 100°C
R-862001	1.08	3.01	0.20	0.90	0.89
R-862002	1.10	3.11	0.17	0.83	
R-862003	1.11	3.01	0.22	0.90	0.86
R-862004	1.09	3.07	0.20	0.90	
R-862005	1.09	3.41	0.32	0.90	0.83

Table 6. TL dating results for ceramics from Præstestien.

Risø TL no.	Feature	Arch no.	TL date
R-862001	Pithouse	JEL	500 AD +/- 80 a
R-862002	"	JEO	810 AD +/- 60 a
R-862003	"	JEP	630 AD +/- 80 a
R-862004	House XXXIX	JKØ	600 AD +/- 80 a
R-862005	House LXV	ODÆ	570 AD +/- 80 a

Except for R-862002, which is slightly more recent than expected, the results agree well with the archaeological estimate.

3. Højgård near Gram

The excavation comprising a settlement with a number of houses with sunken floors and longhouses was carried out in 1985 by Haderslev Museum under the direction of Per Ethelberg (1986a,b,1988). On the basis of the ceramics found, the houses were dated, respectively, to the Late Neolithic or Early Bronze Age. Groups of cooking pits or hearths filled with burnt stones were found in the west end of all longhouses indicating that they belonged to the houses. The TL dating was made on burnt stones from a number of these pits.

The environmental radiation was measured in the pits from which samples were taken for dating (Fig. 3). The results together with beta doses, U-content of grains and fading over four weeks at room temperature and at 100 °C are listed in Table 7. The TL dating results are given in Table 8.

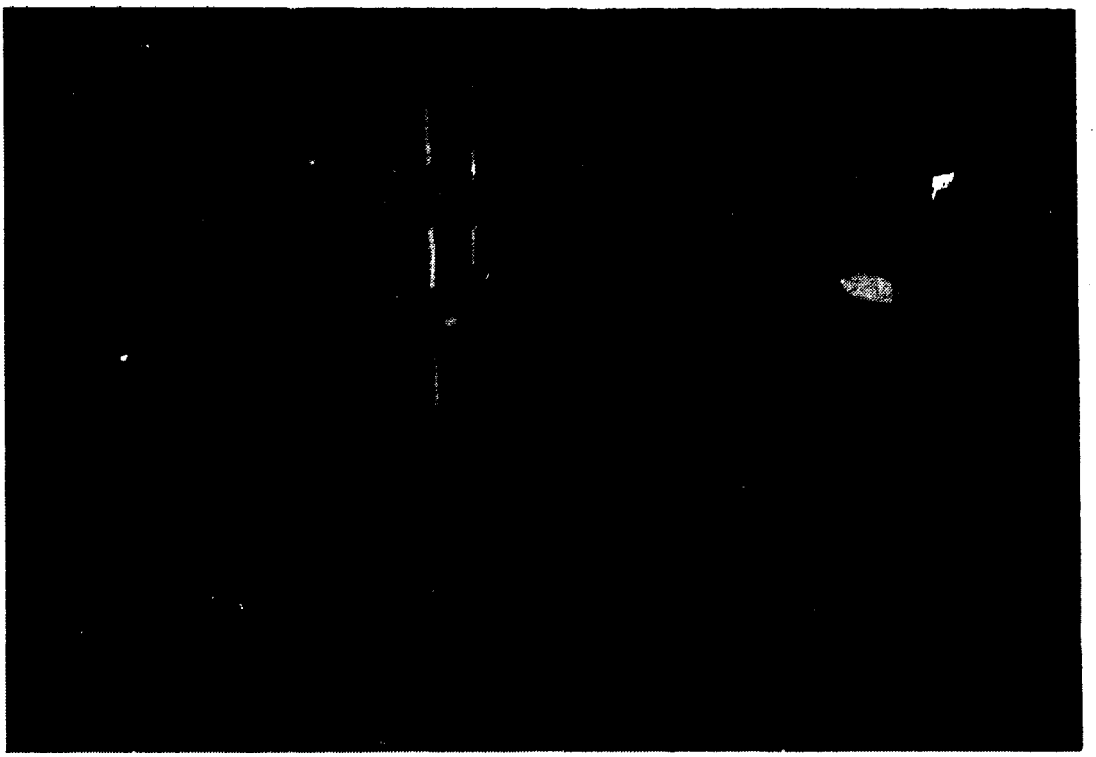

Fig. 3. Measurement of environmental radiation at Højgård, Denmark.

A radiocarbon date (K-4615) made on charcoal from a pit whose filling-layer was covering one of the supposed youngest houses gave the calibrated result 1010 BC +/- 75 a. Assuming that the wood could have an age of up to 100 years at the time of application one can conclude from the radiocarbon result that the TL ages should be older than 900 BC. The TL dates in Table 8 corrected for fading at 20°C show a large scatter, and only four values are older than 900 BC. In three cases (pit no. 829, 836 and 838) two stones from the same pit were dated and while the two results for pit no. 836 are in agreement the results for the pairs from the other two pits differ by 500-600 years, indicating that the results are wrong.

Table 7. Gamma and beta dose rates, U-content of grains and fading over four weeks at 20°C and 100°C for burnt stones from Højgård.

Risø TL no.	Dose rate (mGy/a) Gamma	Beta	U-content (ppm)	Fading, 4 weeks 25°C	100°C
R-851102	0.54	1.94	0.27	0.94	0.92
R-851105	0.52	4.84	0.30	0.95	0.84
R-851106	0.52	6.15	0.19	0.95	0.87
R-851108	0.57	5.95	0.12	1.01	0.80
R-851109	0.79	7.36	0.81	1.02	0.95
R-851112	0.80	4.74	0.79	0.92	-
R-851115	0.82	4.22	0.50	0.98	0.92
R-851117	0.82	3.82	0.50	0.92	0.86
R-851121	0.58	4.88	0.18	0.91	0.62
R-851122	0.58	3.63	0.48	0.86	0.74

Table 8. TL dating results for burnt stones from Højgård. The feldspar results have been corrected for fading at 20°C and at 100°C for four weeks. The total uncertainty is +/- 200 a with the reservation that the correction for fading may be insufficient. Note that the stones were all different even though some have identical archaeological numbers.

Risø TL no.	House	Pit	Sample no.	TL dating results (Fad. 20°C)	(Fad. 100°C)	Fading, 4 weeks 100°C
R-851102	V	822	886	830 BC	850 BC	0.92
R-851105	V	829	887	560 BC	740 BC	0.84
R-851106	V	829	887	1120 BC	1400 BC	0.87
R-851108	V	832	889	1 AD	500 BC	0.80
R-851109	VI	834	890	1120 BC	1280 BC	0.95
R-851112	VI	835	891	690 BC	-	
R-851115	VI	836	892	1110 BC	1310 BC	0.92
R-851117	VI	836	892	980 BC	1190 BC	0.86
R-851121	X	838	894	310 AD	470 BC	0.62
R-851122	X	838	894	190 BC	360 BC	0.74

One reason why results were obtained that were too young could be an insufficient correction for fading. We therefore studied the effect of storing samples for fading at 100°C for four weeks. The resulting corrected values are listed in Table 8. There was a rather large effect on the younger TL dates which increased by up to 500 years. However, the corrected values are still less than expected, indicating that application of such large fading fading corrections is questionable. The effect of the 100°C fading correction on those dates that were in the expected range was much smaller and the corrected dates are still in the expected range. A viable procedure for eliminating errors caused by short-term fading therefore appears

to be to carry out fading tests by storing samples at 100°C and reject those that show a fading greater than say 20%. As indicated by Fig. 1, storage for only two weeks would be sufficient.

4. Hyllerup

The excavation was carried out in 1985 by Jens-Åge Pedersen, The Danish National Museum (Pedersen 1986), and comprised remains of a mound and a house estimated to date to the Older Bronze Age. The TL dating was made on burnt clay found in two postholes of the house. The results obtained are listed below.

Environmental radiation	0.97 mGy/a
Beta dose rate	3.49 "
Ratio wet to dry weight	1.17 "
U-content (estimated)	0.2 ppm
Fading, four weeks	0.95

TL-date (R-852801): 1270 BC +/- 200 a

The TL date obtained from quartz and feldspar agrees well with the expected age. A radiocarbon date (K-4633) was made on unburnt bones from a posthole, but the result, 810 AD, showed that the bones were unrelated to the Bronze Age habitation.

5. Torstorp Nørreby near Tåstrup

The excavation was carried out in 1985 by Søllerød Museum under the direction of Preben Rønne. It comprised a settlement extending from Late Bronze to Early Viking Age (Rønne 1986). Traces of ten houses were found. The TL dating was made on ceramics and burnt clay found in postholes or pits adjacent to houses.

Environmental and beta dose rates, ratio of wet to dry weight, U-content of grains and fading of feldspar grains over four weeks are listed in Table 9 and the TL dating results are given in Table 10. The dating was based on quartz and feldspar.

Three radiocarbon dates have been made on charcoal and the calibrated results are listed below.

K-4946, House IX, hole ZL: 250 - 425 AD
K-4947, House V, hole CX: 240 - 410 AD
K-4948, House VII, pit PA : 770 - 405 BC

K-4948 is considerably older than expected, suggesting that the sample was contaminated with pieces of older charcoal as it contained several tree sorts (H. Tauber in letter of 4th September 1987 to E. Fonnesbech-Sandberg).

Table 9. Ratio of wet to dry weight (W), gamma and beta dose rates, U-content of feldspar grains and fading of feldspar for ceramics (C) and burnt clay (L) from Torstorp Nørreby.

Risø TL no.	Material	W	Dose rate (mGy/a) Gamma	Beta	U-content (ppm)	Fading, 4 weeks
R-863908	C	1.13	1.01	3.91	0.20	1.00
R-863909	L	1.15	1.01	2.72	0.20	0.94
R-863910	C	1.13	0.93	3.73	0.20	0.97
R-863911	C	1.12	0.92	3.32	0.20	0.97
R-863912	C	1.14	1.00	3.91	0.20	0.95
R-863913	L	1.16	1.00	2.94	0.20	1.00
R-863914	C	1.11	1.00	3.28	0.21	1.01
R-863915	C	1.16	0.90	3.82	0.20	0.84
R-863916	L	1.14	1.00	2.79	0.20	1.00
R-863917	L	1.21	1.00	2.32	0.20	0.95
R-863918	L	1.14	1.00	2.54	0.20	1.00

Table 10. TL dates for ceramics and burnt clay from Torstorp Norreby. C = ceramics, L = clay. The holes mentioned are postholes.

Risø TL no.	Material	House	Feature	TL age (a)	TL date
R-863908	C	IV	Pit HG	2457	410 BC +/- 150 a
R-863909	L	IV	Hole GL	2325	
R-863910	C	X	Hole BT	2737	750 BC +/- 180 a
R-863911	C	X	Pit BW	2214	230 BC +/- 180 a
R-863912	C	I	Pit ADA	1966	120 +/- 150 a
R-863913	L	I	Pit ADA	1769	
R-863914	C	II	Pit AW	1810	180 AD +/- 150 a
R-863915	C	IX	Hole ZL	1742	240 AD +/- 150 a
R-863916	L	VII	Pit PA	1573	410 AD +/- 100 a
R-863917	L	V	Hole CX	1238	720 AD +/- 80 a
R-863918	L	V	Hole DA	1291	

The TL date, R-863915, for house IX is in good agreement with K-4946 whereas the TL result for house V (R-863917 and R-863918) is somewhat more recent than K-4947. An archaeological estimate (E. Fonnesbech-Sandberg, personal communication) places house V around 600 AD, i.e. somewhere between the TL and radiocarbon dates. The remaining TL results are in good agreement with archaeological estimates except those for house X which are older than expected. The original archaeological estimtate was between 100 and 200 AD. However, based on house typology a Pre-Roman date for house X appears acceptable (E. Fonnesbech-Sandberg, personal communication).

TL DATING RESULTS, SWEDEN

A total of 14 samples from 2 sites were dated and the results are described below.

1. Kasby near Uppsala

The TL dating was made on a brick from the basement of a manor and a brick and three roof tiles from an adjacent smaller house (Fig. 4). The samples were submitted by Olof Antell, Riksantikvarieämbetet, Stockholm.

The environmental radiation was measured by scintillation counting in August 1985 and also by placing TL dosemeters ($CaSO_4$:Dy) from August 1985 to August 1986. Some of the dosemeters placed on the roof of the small house gave erroneously high readings because of fallout from Chernobyl.

Table 11. Ratio of wet to dry weight (W), gamma and beta dose rates, U-content of feldspar grains and fading of feldspar over four weeks for bricks and roof tiles from Kasby.

Risø TL no.	W	Dose rate (mGy/a) Gamma	Beta	U-content (ppm)	Fading, 4 weeks
R-850901	1.18	1.14	3.79	0.20	0.89
R-850902	1.18	1.22	4.21	0.36	0.91
R-850903	1.17	0.89	4.93	0.20	0.92
R-850904	1.17	0.89	4.72	0.20	0.94
R-850906	1.13	0.89	4.59	0.24	1.01

Ratio of wet to dry weight, gamma and beta dose rates, U-content of grains and fading over four weeks are given in Table 11 and the TL dating results are listed in Table 12. It was assumed that the bricks from the houses had been dry all the time and that the roof tiles had been dry for five months and saturated with water for seven. The results agree well with expected ages.

Fig. 4. Small house belonging to a manor in Kasby. Three roof tiles from the small house were submitted for TL dating.

Table 12. TL dating results for bricks and roof tiles from Kasby.

Risø TL no.	Feature	TL age (a)	TL date
R-850901	Basement, manor	339	1650 AD +/- 40 a
R-850902	Stove, small house	194	1790 AD +/- 30 a
R-850903	Tile 1	163	1820 AD +/- 30 a
R-850904	Tile 2	171	
R-850906	Tile 4	173	

2. Hill-forts in the Angermanjö area

TL dating of burnt stones from two ancient hill-forts, Lingsberg and Rävsta, studied by Michael Olausson from the Institute of Archaeology, Stockholm University was described by Mejdahl (1986). In 1986 samples of burnt stones were collected from an enclosed settlement: Lunda (monument no. 7), and two hill-forts: Frösunda Berg (monument no. 3) and Olhamra near Vallentuna (monument no. 231). The environmental radiation was measured during sample taking.

Gamma and beta dose rates, U-content of feldspar grains and fading of feldspar after storage for two weeks at 100°C are given in Table 13 and the TL dating results are given in Table 14. A number of radiocarbon dates from the same sites are shown in Table 15.

Table 13. Gamma and beta dose rates, U-content of feldspar grains and fading of feldspar over four weeks for burnt stones from Lunda, Frösunda Berg and Olhamra.

Risø TL no.	Dose rate (mGy/a) Gamma	Beta	U-content (ppm)	Fading, 2 weeks at 100°C
R-864401	1.48	11.73	2.0	0.95
R-864403	1.48	3.37	0.1	0.95
R-864405	1.70	3.91	0.5	1.00
R-864406	1.70	5.71	0.5	0.99
R-864408	1.26	2.08	0.5	1.00
R-864411	1.56	4.23	0.3	1.00
R-864412	1.56	5.36	0.4	1.00
R-864413	1.56	6.92	0.5	1.00
R-864414	1.56	6.24	1.0	0.96

Table 14. TL dates for burnt stones from Lunda, Frösunda Berg and Olhamra.

Risø TL no.	Locality	Monument no.	TL age (a)	TL date
R-864401	Lunda, shaft 2	7	2253	130 BC +/- 150 a
R-864403	" "	"	1931	
R-864405	" shaft 1	"	2003	
R-864406	" "	"	2270	
R-864408	Frösunda Berg	3	1387	600 AD +/- 150 a
R-864411	Olhamra, shaft 2	231	2161	280 BC +/- 150 a
R-864412	" "	"	2441	
R-864413	" "	"	2240	
R-864414	" "	"	2207	

Table 15. Calibrated radiocarbon dates (Stuiver and Becker 1986) for samples from Lunda, Frösunda Berg and Olhamra.

C-14 No.	Site	C-14 date
St-10879	Lunda, shaft 1	150 - 350 BC
St-10880	Lunda, shaft 2	50 - 350 BC
Ua-434	Frösunda Berg	430 - 190 AD
St-8041	Olhamra, shaft 1	200 - 470 BC
St-8292	Olhamra, shaft 1	640 - 440 AD

The C-14 and TL results for Lunda can be compared directly and are in good agreement. For Frösunda the TL date is about 200 years younger than the upper limit of the C-14 range, a difference which appears too large to be explained by a possible inherent age of the wood used for C-14 dating. For Olhamra the results cannot be compared directly because the samples came from different shafts. In shaft 1 an outer younger layer could be distinguished stratigraphically, as reflected in the radiocarbon dates; this was not the case for shaft 2 where the sample for TL dating was taken. The TL date for shaft 2, 280 BC, agrees well with the older radiocarbon date for the inner layer in shaft 1.

TL DATING RESULTS, NORWAY

1. Church ruin at Sola

The church ruin (Fig. 5) was excavated by Alf Tore Hommedal, Riksantikvaren, Bergen (Hommedal 1986 a, b). During the excavation a mould for church bell casting was found inside the church. The mould was thus

more recent than the building of the church and the estimated age was 1300 - 1400 AD. The TL dating was made on a lump of burnt clay from the mould.

The radiation field in the pit was not uniform because of the presence of a number of large granite stones. Measurements with the probe surrounded by soil gave the result 1.23 mGy/a while measurements near a large stone gave 1.80 mGy/a. The mean value 1.52 mGy/a was used for the calculation of age. The resulting uncertainty +/- 0.28 mGy/a gave rise to an uncertainty of 5% in the total dose rate.

The ratio of wet to dry weight, U-content of feldspar grains, gamma and beta dose rates, fading over four weeks and the TL date obtained are given in Table 16.

Fig. 5. The Sola church ruin . After a drawing made in 1852 by Bernard Hansson. From Hikuin 12, 1986.

Table 16. Ratio of wet to dry weight (W), U-content of feldspar grains, gamma and beta dose rates, fading of feldspars over four weeks and TL date for burnt clay from Sola church ruin.

Risø TL no.	W	Dose rate (mGy/a) Gamma	Beta,dry	U-content (ppm)	Fading, 4 weeks at 100°C	TL date
R-861901	1.18	1.52	4.67	0.05	0.88	1380 AD +/- 40 a

During the excavation a number of coins were found. The youngest of these had been stamped somewhere between 1320 and 1380/1400 AD. The casting of the bell must, therefore, have taken place after 1320 AD. The TL date is in good agreement with the evidence provided by the coins.

TL DATING RESULTS, FINLAND

1. Bricks from Finnish churches and Sveaborg

A number of bricks from four Finnish churches, Esbo, Pyrkslätt, Lojo (Fig. 6) and Rengo and from the Sveaborg castle outside Helsinki have been submitted for TL dating by Högne Jungner, The Radiocarbon Laboratory, and Markus Hiekkanen, Museiverket, Helsinki. Archaeomagnetic studies were carried out on the same bricks (Hiekkanen 1985), but results are not yet available for comparison.

The samples were collected during restauration of the churches (Hiekkanen 1985). Because the background radiation was not measured at the time, it has been difficult to obtain a realistic estimate of this component. An attempt was made to measure the radiation in three churches (Esbo, Kyrkslätt and Lojo) by scintillation counting. Reasonably realistic estimates were obtained for Esbo and Lojo whereas the relevance of the results obtained for Kyrkslätt is questionable.

Ratios of wet to dry weights, gamma and beta dose rates and fading over four weeks are listed in Table 17, and the TL dates obtained are given in Table 18. It was assumed that the water content of the samples in situ was half that at saturation.

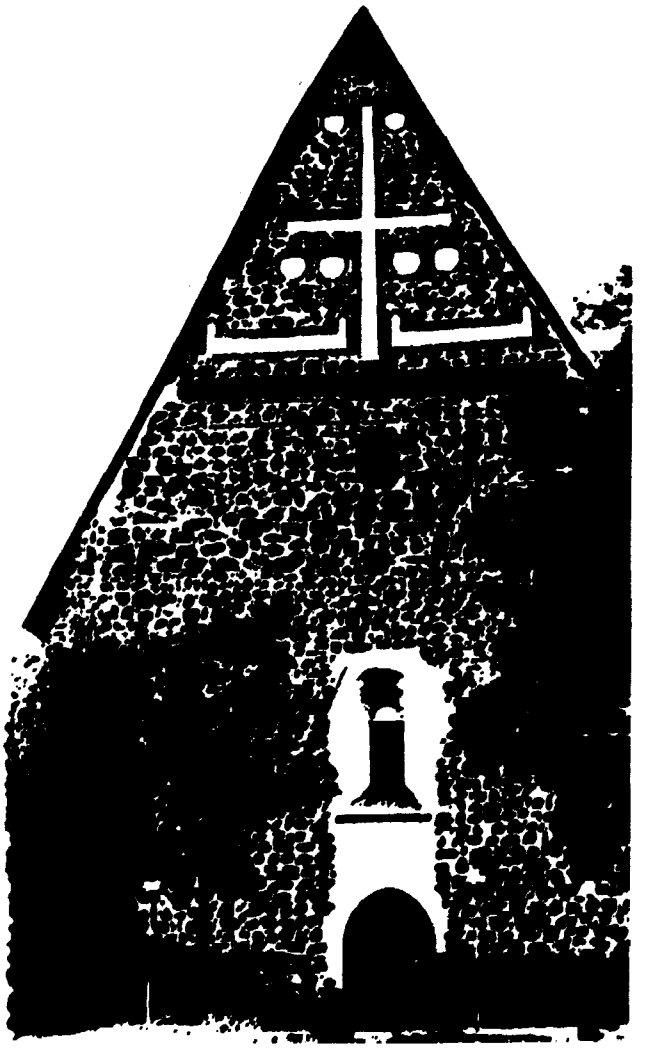

Fig. 6. The church of St. Lawrence in Lohja.

The U-content of the grains could not be measured correctly for most samples because they contained too many clay particles or red grains. A U-content of 0.1 ppm, estimated from measurements on two clean samples, has been used for all samples.

In most cases the TL dates are somewhat more recent than expected. Good agreement with expected age was found for Lojo where the best estimate of the background radiation was obtained. Two of the results from Esbo also agree with expected ages within the uncertainty of the results. The results indicate that TL-dating could be a very useful technique for dating churches provided that the background radiation can be measured accurately.

Table 17. Ratio of wet to dry weight (W), gamma and beta dose rates and fading of feldspars over four weeks for bricks from Finnish churches. Gamma dose rates for Rengo and Sveaborg were estimated.

Risø TL no.	Locality	W	Dose rate (mGy/a) Gamma	Beta	Fading, 4 weeks
R-851308	Esbo	1.14	1.30	4.04	0.96
R-851309	"	1.19	1.30	3.78	0.96
R-851310	Kyrkslätt	1.08	1.30	4.11	1.00
R-851311	"	1.06	1.30	4.50	1.00
R-851312	Lojo	1.16	1.12	3.81	0.90
R-851313	Rengo	1.20	1.20	3.10	0.93
R-851314	"	1.19	1.20	3.32	0.91
R-851315	Sveaborg	1.10	1.20	4.20	0.94
R-851316	Esbo	1.14	1.30	3.76	0.94

Table 18. TL dates for bricks from Finnish churches and Sveaborg. The uncertainty was estimated to +/- 50 years.

Risø TL no.	Arch. no.	Church	TL date (AD)	Expected date (AD)
R-851308	ML 1	Esbo	1540	~ 1450
R-851309	ML 2	"	1740	1650 - 1700
R-851310	ML 3	Kyrkslätt	1540	1300 - 1400
R-851311	ML 4	"	1770	1300 - 1400
R-851312	ML 5	Lojo	1490	1450 - 1500
R-851313	ML 6	Rengo	1520	1450 - 1500
R-851314	ML 7	"	1580	1450 - 1500
R-851315	ML 8	Sveaborg	1830	~ 1750
R-851316	ML 9	Esbo	1520	~ 1500

CONCLUSION

A total of 56 TL dating results representing 14 sites are discussed. In most cases the TL dates were in good agreement with other dating evidence.

Inconsistencies were encountered for samples from Højgaard where several TL dates appeared to be too recent. Fading tests made on samples stored at 100°C showed a large short-term fading (up to 40%) for those samples that yield dates that were too recent. Consequently, storage of samples at 100°C for fading tests has now been adopted as a standard procedure and samples showing more than 20% fading are discarded. With this precaution it appears possible to eliminate errors caused by short-term fading.

ACKNOWLEDGEMENTS

It is a pleasure to thank the excavation directors for many interesting and useful discussions concerning their sites. I am grateful to Dr. H. Kunzendorf for permission to use the delayed neutron counting facility and to Mr. P. Jensen for carrying out the measurements. Last, but not least, I thank the members of the staff at the Nordic TL Laboratory, M. Adrian, E. Andersen, V. Emborg, L. Farina and H. Wojtaszewski for skilful assistance.

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Risø National Laboratory **Risø – M – 2658**

Title and author(s)

A Survey of Archaeological Samples Dated in 1986

Vagn Mejdahl

Date October 1987

Department or group The Nordic Laboratory for Thermoluminescence Dating

Groups own registration number(s)

Project/contract no.

Pages 31 **Tables** **Illustrations** **References**

ISBN

Abstract (Max. 2000 char.)

A survey is given of archaeological samples dated in 1986 at the Nordic Laboratory for Thermoluminescence Dating. A total of 56 samples were dated. The results were corrected for short-term fading as measured for samples stored for four weeks at room temperature or at 100°C. The beta dose from potassium and rubidium in feldspar and the alpha dose from uranium and thorium in quartz and feldspar grains were included assuming alpha efficiency factors of 0.1 and 0.2 for quartz and feldspar, respectively.

Descriptors

AGE ESTIMATE; ARCHAEOLOGICAL SPECIMENS; DENMARK; FINLAND; NORWAY; SWEDEN; THERMOLUMINESCENCE

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ISBN 87-550-1344-9
ISSN 0418-6435